TREE HEALTH ANALYSIS FOR APOCYNACEAE, MYRISTICACEAE, FLACOURTIACEAE, ACHARIACEAE AND SALICACEAE FAMILIES IN BOGOR BOTANICAL GARDEN (BBG)

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Bogor, September 2021

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ABSTRACT

AULIA RAHMA AMALIA RIDWAN. Tree Health Analysis for Apocynaceae, Myristicaceae, Flacourtiaceae, Achariaceae, and Salicaceae Families in Bogor Botanical Gardens (BBG). Supervised by ELIS NINA HERLIYANA, and ARIEF NOOR RACHMADIYANTO.

Bogor Botanical gardens (BBG) is a world professional plant collection with important assets whose existence needs to be maintained. Tree damage in BBG should be recognized appropriately by knowing the type and location as well as the extent of the damage. The type of damage is commonly found is Heart rot, Weathered wood, Gall Rust of 36% of the total cases found. Damage's area to the tree found a total of 9 areas with as much damage as it was located on the midway between crown and stump is as much as 45%. About 50 % of total tree damage is very healthy with Cluster Level Index's score is 2.93, and a study site can be categorized as normal or healthy. Organization of trees with the value of the mischief to the trees should be checked consistently utilizing FHM technique and the information of the presence of such trees makes certain to be encouraged to the visitors, so they can travel safety.

Keywords: Forest health monitoring, level health of trees, location, severity, tree damage

ABSTRAK

AULIA RAHMA AMALIA RIDWAN. Tree Health Analysis for Apocynaceae, Myristicaceae, Flacourtiaceae, Achariaceae, and Salicaceae Families in Bogor Botanical Gardens (BBG). Dibimbing oleh ELIS NINA HERLIYANA, dan ARIEF NOOR RACHMADIYANTO.

Kebun Raya Bogor (KRB) merupakan tempat koleksi tumbuhan kelas dunia dengan aset penting yang keberadaannya perlu dipertahankan. Kerusakan pohon di KRB harus dikenali secara tepat dengan mengetahui jenis dan lokasi serta tingkat kerusakannya. Jenis kerusakan yang sering ditemukan adalah busuk hati, kayu lapuk, dan karat tumor sebesar 36% dari total kasus yang ditemukan. Kerusakan pohon yang ditemukan di 9 lokasi dengan jumlah kerusakan yang terbanyak terletak di tengah-tengah antara dasar tajuk dan batang bagian bawah adalah sebesar (45%). Sekitar 50% pohon dikategorikan sangat sehat dengan nilai Plot Level Index 2.93, sehingga pada lokasi penelitian dapat dikategorikan normal atau sehat. Pengelolaan arboreal pada pohon dapat diperiksa dengan baik menggunakan metode *FHM*, dan informasi mengenai keberadaan pohon-pohon ini perlu didorong untuk memastikan bahwa pengunjung dapat berwisata dengan aman.

Kata kunci: Pemantauan kesehatan hutan, tingkat kesehatan pohon, lokasi kerusakan, tingkat keparahan, kerusakan pohon

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PREFACE

The author would like to pray to Allah subhanaahu wa ta'ala for all His gifts so that this scientific work has been completed successfully. The theme chosen in the research which was carried out from February 2021 to May 2021 was *Forest Health Monitoring* entitled "Tree Health Analysis for Apocynaceae, Myristicaceae, Flacourtiaceae, Achariaceae, and Salicaceae Families in Bogor Botanical Gardens (BBG)".

The authors would like to thank the supervisors, Dr Ir Elis Nina Herliyana MSi, Dr Erianto Indra Putra SHut, MSi, and Arief Noor Rachmadiyanto SP MP who have guided and provided many suggestions. Thanks are also conveyed to seminar moderators, and examiners outside the supervisory commission. In addition, the author's appreciation goes to the Head of the Research Center for Plant Conservation and Botanical Gardens-LIPI and his staff who have granted research permission. Expressions of gratitude are also conveyed to the author's beloved father, lovely mother, and three younger siblings who have provided support, prayers, and affection. Expressions of gratitude are also conveyed to me-my self-and *i*, *Sahabat Bentar doang*, and families of fahutan 54 who have helped the author navigate college life for 4 years.

Hopefully, this scientific work is useful for those who need it and for the advancement of science.

Bogor, September 2021

Aulia Rahma Amalia Ridwan

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I INTRODUCTION

1.1 Background

One form of the hometown forest of Bogor is Bogor Botanical Gardens (BBG). Botanical gardens are known as ex-situ conservation areas which have a collection of plants of 22 families, 125 genera of 3.423 species, and 13.563 specimens located on an area of 87 hectares (Miardini 2006). Bogor Botanical Gardens has a vision of becoming a world-class botanical garden, especially in the field of plant conservation, research, and services. in the aspects of botany, environmental education, horticulture, landscaping, and tourism (Helmanto *et al.* 2018). Botanical Gardens have an international task to implement the *Global Strategy for Plant Conservation* (GSPC) to save the world's plants (Davis 2008).

Bogor Botanical Gardens is a big asset in the field of education and tourism. A tree as the main object, which is an attraction KRB expected assured of his health to provide safe and comfortable for the visitors. Within the framework of the health of the forest, an individual tree will be incorporated into the constituent populations of the garden, and therefore, the health of the trees as individuals should be very concerned at a most. The death of an individual tree can be a problem and it is important to note because it may lead to the deterioration of the population. Health monitoring efforts can have implications for guaranteeing the feasibility of BBG as a world botanical garden with trees as the main object in its observations. One of the forest health monitoring systems whose assessment system is based on forest ecological components is *Forest Health Monitoring* (FHM).

FHM was originally designed to monitor forest conditions in the America and temperate countries by Mangold (1997), then applied in Indonesia with various adjustments, including damage to trees caused by lianas and wood decaying by fungi. Putra (2010) states that this method predicts and provides information regarding current forest conditions, changes, and trends that occur in forest areas. This is done using ecological indicators that are measured at the verifier level in quantifying forest health parameters.

Ebbels (2003) explains that tree health diagnosis is a process of observation based on natural symptoms and signs caused by disease, insect pests, weeds, fire, weather, animals, as well as due to human activities and various other abiotic factors. Damage to trees in BBG should be detected early by knowing the level of damage assessed in terms of the type of damage, the part of the tree with damage, and the severity of the damage. BBG collection plants consist of thousands of types arranged based on family groups comprised of the plot (PKT-BBG 2021). Based on purposive sampling, primary data assessment of tree health status was conducted in Cluster 2 FHM BBG that dominated by the families Apocynaceae, Myristicaceae, Flacourtiaceae, Achariaceae, and Salicaceae.

The conservation of the existence of BBG as a world botanical garden can be done by preserving the collection tree with the maintenance and care of the trees. Early detection allows treatment measures for diseased trees to minimize tree damage and avoid casualties. Botanical garden visitors generally have recreational purposes, so the safety of visitors needs to be considered. Therefore, the information provided in the form of tree damage will guarantee the safety of visitors so that they feel safe and comfortable while on recreation.

1.2 Problem Formulation

Bogor Botanical Gardens has a collection of various plants which are a form of *ex-situ* conservation function for Indonesian plants. However, the collection information available at the Bogor Botanical Gardens is limited to kingdom plantae or plants only. Updates on collection information are also not carried out periodically and lead to damaged plants. The inventory of plant species diversity in the Bogor Botanical Gardens is expected to be able to add and update information on existing plant species diversity, so that the plant species data can be used as a basis for further management actions. The main objective of this study is to determine the condition of the trees so that they can provide recommendations for treatment and prevention of tree damage in the Bogor Botanical Gardens.

1.3 Purpose of Research

This study aims to determine the health condition of the trees of Apocynaceae, Myristicaceae, Flacourtiacceae, Achariaceae, and Salicaceae Families in the Bogor Botanical Gardens and to provide recommendations for the treatment and prevention of tree damage in the Bogor Botanical Gardens.

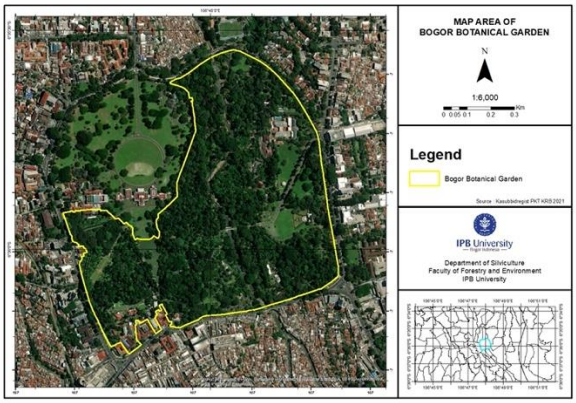
1.4 Benefit of Research

Results of this study are expected to provide additional information about the diversity of existing plant species and provide recommendations for treatment and prevention of tree damage which can be taken into consideration for ex-situ conservation management of Bogor Botanical Gardens.

II METHODS

2.1 Times and Places

This research included data collection activities carried out from March to April 2021 at the Bogor Botanical Gardens, analysis, and processing of forest health data in April 2021 at the Forest Pathology Laboratory, Department of Silviculture, Faculty of Forestry and Environment, IPB University.



Source: Head of Registration Subdivision BBG 2021
Figures 1 Map of Bogor Botanical Garden

2.2 Tools and Materials

The tools used in this study were a map of the Bogor Botanical Gardens, *phi-band,* diameter tape, *Haga hypsometer*, camera, stationery, compasses, GPS (Global Positioning System), and installed laptop application MS Excel. The materials used in this study are the trees of Apocynaceae, Myristicaceae, Flacourtiaceae, Achariaceae, and Salicaceae Families.

2.3 Research Procedures

2.3.1 Making Plot Observation

Making observation plots using Forest Health Monitoring (FHM) cluster plots. The FHM plot cluster represents a forest area of 1 ha comprised of 4 annular plots in the shape of a circle with a radius of 17.95 m, inside the annular plot there is a subplot with a radius of 7.32 m and a micro plot with a radius of 2.07 m. The 36.6 m distance from plot 1 with azimuth 0, 120, and 240 is the center point of plot 2, plot 3, and plot 4. then there is a 3 point between plots 1 and 2, plots 1 and 3, plot 1 and 4 for sampling the soil in the composite, while the provision of several trees is done in a clockwise direction based on the azimuth and distance of the flat to the center point of the plot (Figure 2) The annular plot in this method consists of 4 for each cluster, On the annular plot of data taken from the tree while the subplots just to the pole, and for a soil sample that will be tested for the fertility of the soil and other things taken in the micro plot.

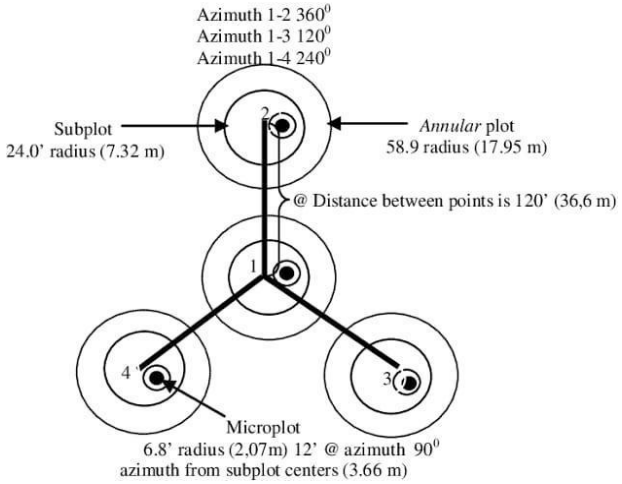


Figure 2 FHM Cluster Plot Design (USDA-FS 1997)

2.3.2 Data Collection

Primary data based on purposive sampling was taken in Cluster 2 FHM BBG with a total of 64 trees. The primary data collected are tree species, diameter at breast high, total height, tree damage condition, and tree coordinates. The census visited trees in each selected plot, and the diameter, height, and condition of their coordinates were taken. Measuring the diameter and height is needed to determine the growth indicators. In the Forest Health Monitoring method, signs and symptoms of damage are recorded based on the definition that damage can kill the tree or affect the tree's long-term survival. Observations of trees are carried out on the entire side starts from the root up to the top of the tree.

Impression of the condition of the damage done on each tree through the assessment of the damage location, types of damage, and severity of damage. The damage location starts from the root to the top of the header with the code sequentially from 01 to 09 (Table 1). The damage occurred is recorded with the record of types of damage and value of the threshold of severity (Table 2). If a tree has more than three damage, three damage at first experienced to start from the root is noted (Putra 2004). Severity level of damage recorded in class 10-99% away from the value of the constraint of reality. Any damage that doesn't meet the restriction of severity isn't recorded into the tally sheet (Table 3).

Table 1 The description of the location of the damage (USDA-FS 1997 in Muyasara 2019)

Code	Descriptions
0	No damage
1	The roots of the open and“stump”(12 inches (30 cm) above the soil surface)
2	Damage to the roots and between the roots and stems of the bottom
3	Damage on the trunk of the bottom (below the mid between “stump” and the basic crowns)
4	Damage on the stem of the lower part of which there is also in the trunk the top

5	Damage on the stem of the upper part (above the middle between the "stump" and the basic crowns)
6	Damage to the main boughs contained in the header section, above basic header
7	Damage on a twig (branches and small branches other than main boughs)
8	Damage on young leaves and shoots
9	Damage on the crowns

Table 2 Description of the types of damage and value of the threshold of severity (USDA-FS 1997 in Nuhamara *et al.* 2001)

Code	Descriptions	Threshold Values of Severity (10-99%)
1	Stem Cancer	≥ 20% of the observation point
2	Heart rot, Weathered wood, Gall Rust (tumor)	20% at the root of 3 feet (0.91 m) from the trunk
3	Open wounds	≥ 20% of the observation point
4	Resinosis/gummosis	≥ 20% of the observation point
5	Cracks and Seams	≥ 1.52 m in length and on at least 20% of the branches
6	Termites' gallery	≥ 20% of the observation point
7	Liana	≥ 20% of the observation point
11	Stem or root fracture > 3 feet (0.91 m) from stem	-
12	Brum at the root or stem	-
13	Broken root or dead > 3 feet (0.91 m) from the trunk	≥ 20% at the root
20	Vines in the crown	≥ 20% of live crown affected
21	The loss of the apical of the dominant, dead	≥ 1% on a limb on the header
22	Broken branches or dead	≥ 20% on the twigs or shoots
23	Branching or brum excessive	≥ 20% on the twigs or shoots
24	Leaves, buds, or shoots damaged	≥30% of the foliage closing header
25	Leaves change colour (not green)	≥30% of the foliage closing header
31	Other	-

Table 3 Description of the grade of severity of damage (Supriyanto and Kasno 2001)

Code	Severity Class (%)
0	01 – 09
1	10 – 19
2	20 – 29
3	30 – 39
4	40 – 49
5	50 – 59
6	60 – 69

7	70 – 79
8	80 – 89
9	90 – 99

2.4 Data Analysis

According to Khoiri (2004), a damage assessment uses criteria based on the FHM method. The data obtained from the damage assessment has calculated the value of the damage index with the code and weighted value of the damage index (TLI). The results of the final calculation can be known as TLI (healthy class, light class, medium class, and heavy class).

$$\text{TLI} = \sum_{i=1}^{n=64} (x\,\text{Location} \times y\,\text{Type of damage} \times z\,\text{Severity})$$

Description: Tree Level Index is the summation of the damage, on a tree that has more than one damage. x,y,z is the value of weighting the amount of which will vary depending on the level of relative data of each component to the growth and resilience of the tree (Table 4).

$$\text{PLI} = (\Sigma\, TLI \text{ in the plot} / \Sigma \text{ trees in a plot})$$

Description: The Plot of the Level of the Index that is the average damage from tree 1 to tree n. The value of TLI high and low became the basis of the formation of a score based on the value of PLI (Table 5). The average damage from 1st tree to 64th tree in a plot so that the class of tree damage can be found based on the weighted index value with the following criteria:

Healthy class : 0 - <5
Class of light damage : 6-10
Moderate damage class : 11-15
Heavy damage class : 16 -> 21

Table 4 Value of the weighting for each of the locations, damage, and severity (Putra 2004)

Location Code	Score	Damage Code	Score	Severity Code	Score
0	0	11	2.0	1	1.1
1, 2	2.0	1	1.9	2	1.2
3, 4	1.8	2, 6	1.7	3	1.3
5	1.6	12	1.6	4	1.4
6	1.2	3, 4, 5, 13	1.5	5	1.5
7, 8, 9	1.0	7, 21	1.3	6	1.6
		22, 23, 24	1.0	7	1.7
				8	1.8
				9	1.9
				0	1.5

Table 5 Value score of the damage to the tree based on the value of PLI (Putra *et al.* 2019)

Average PLI	Score
0	10
0.01 – 0.54	9
0.55 – 1.08	8
1.09 – 1.62	7
1.63 – 2.16	6
2.17 – 2.70	5
2.80 – 3.24	4
3.25 – 3.78	3
3.79 – 4.32	2
4.33 – 4.86	1
4.87 – 5.40	0

III RESULTS AND DISCUSSIONS

3.1 General Condition of Bogor Botanical Garden

The history of Bogor botanical garden started from 1817 when German scientist, Prof CG Carl Reindwardt who asked for a patch of land for the botanical garden, then he collected plants from all over the archipelago. Over time, BBG developed into a research center in the field of botany, with the full name of the Bogor Botanical Gardens-Plant Conservation Center (PKT-BBG) under the auspices of the Indonesian Institute of Research and Research (LIPI).

PKT-BBG has a research and conservation functions including conserve the diversity of plant species ex-situ and strive for the recovery of endangered plant species and the restoration of degraded land, present information in the field of conservation, botany, and environment for visitors, implementing and facilitating research activities in the field of conservation, domestication, and reintroduction of plants, botany, and economics, creating natural tourism, and provide ecological impact for improving environmental quality such as water system, biodiversity, carbon sequestration, and landscape beauty (PKT-BBG 2021).

Bogor Botanical Garden has an area of 87 hectares, situated between 106°43'30" - 106°52'00"E and 6°30'30" - 6°41'00"S. Located at an altitude of 235-260 m asl and administratively located in Bogor City with the boundary of the next area is Jalak Harupat street, south with Otto Iskandardinata Street, Padjajaran street in the east, and the west with Ir H Djuanda street. BBG's topographical state has a flat slope that ranges from 3-5% and is traversed by the Ciliwung River and its tributaries, and the Cibatok River. Isnaini and Novitasari (2019) stated that the average temperature is 25°C, the humidity ranges from 78.27-93.70%, rainfall with an average of 4.330 mm/year, and wind speed ranges between 0.34-0.67 km/h.

3.2 Measurement of Forest Health Indicators

Supriyanto *et al.* (2001) stated that forest health assessments are conducted using indicators of quality, vitality in the form of conditions and tree damage, tree growth, and productivity. Parameter measurement of forest health ecological indicators is done first before analyzing the data and determining the health status of the forest.

Inventory of trees conducted by observing DBH and categorizing stands into sapling, pole, and tree classes is used for productivity indicator assessment. LBDS with DBH data for assessment of plant growth indicators following Clines (1995) statement that Basic Field Area Growth is commonly used as tree growth. The quality indicators use soil fertility data represented by KTK values. Putra (2004) states that the tree observed the condition in fhm method is measured based on several parameters including Live Crown Ratio (LCR), Crown Density (CDen), Folliage Transparency (FT), Crown Dieback (CDb), Crown Diameter Width (CDW), and Crown Diameter 90°. Tree damage conditions are measured starting from the damage site, the type of damage, and the severity of the damage.

3.2.1 Tree Damage

Table 6 The type of Damage and Location of Trees damaged in Cluster 2 FHM BBG

Codes	Damage	Total	Location								
			1	2	3	4	5	6	7	8	9
1	Cancer	7	-	2	3	2	-	-	-	-	-
2	Heart rot, Weathered wood, Gall Rust (tumor)	18	-	4	5	6	1	1	1	-	-
3	Open Wounds	4	-	1	3	-	-	-	-	-	-
4	Exudation	-	-	-	-	-	-	-	-	-	-
5	Cracks and Seams	-	-	-	-	-	-	-	-	-	-
6	Termites Gallery	-	-	-	-	-	-	-	-	-	-
7	Liana Woody	14	-	-	1	13	-	-	-	-	-
11	Broken Stem	1	-	-	1	-	-	-	-	-	-
12	Malformation	-	-	-	-	-	-	-	-	-	-
13	Broken Root	1	1	-	-	-	-	-	-	-	-
20	Vines in the Crown	-	-	-	-	-	-	-	-	-	-
21	Dead end or Buds	-	-	-	-	-	-	-	-	-	-
22	Broken Branches	1	-	-	-	-	-	-	1	-	-
23	Brum Excessive	-	-	-	-	-	-	-	-	-	-
24	Leaves, Leaf Buds, and Shoots Damaged	1	-	-	-	-	-	-	-	-	1
25	Leaves aren't Green	-	-	-	-	-	-	-	-	-	-
31	Others	-	-	-	-	-	-	-	-	-	-

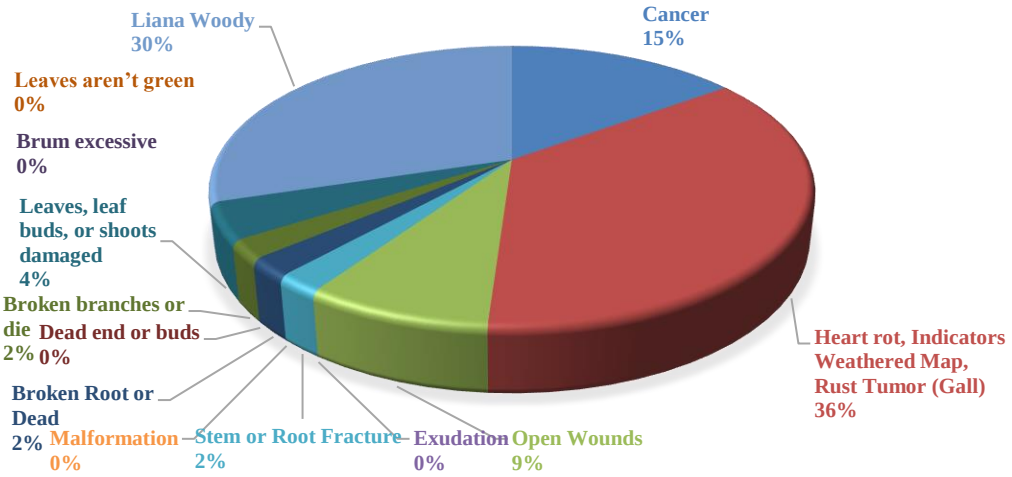


Figure 3 Percentage of Type Damage Cases found in Cluster 2 FHM BBG

The intensity of the damage experienced by each tree different because the sensitivity of the plants is susceptible are also different. The disturbed physiological processes of the plants damage to the tree or disruption of the growth of the tree. The case of damage to the trees found in the study site as many as 55 cases with 8 of the 16 types of damage, as well as 8 of 9 the location of the damage, with the

varies level of severity. The type of damage found in cluster 2 BBG with the percentages shown in Figure 3. Based on the picture above, the type of damage that dominates is the Heart rot, tumors, and weathered wood (36%). Furthermore, with a percentage of 30% no cause damage to trees by Lianas Woody.

Types of Tree Damage in Cluster 2 FHM BBG

Stem Cancer

One of the plant diseases that often arise and can provide a heavy impact is cancer. In general, cancer is caused by a fungus or bacteria. The abnormality of the shape of the tree's trunk results from the presence of a cancer stem (Yusran *et al.* 2006). Based on observations in the field, the trees affected by cancer can still survive, although there is an abnormality in the shape of the trunk. The cancer is on the trunk of the bottom or base of the stem indicates the pathogenic cause of cancer infects through the base of the stem or the roots through the open wound.

Case of damage to the tree with the type of cancer on the study location obtained a total of 7 points or 15% of the overall point of damage. Symptoms of cancer occur in the *Dillenia retusa* Thunb. var. integra Boerl., *Dillenia retusa* Thunb., *Hemiscolopia trimera* (Boerl.) v. Slooten, *Sarcocephalus coadunat* (Roxb, Ex Sin), *Hydnocarpus anthelminthica* Pierre ex Laness., *Lucuma grandiflora* A. DC.and *Alstonia scholaris* (L.) R. Br. Cancer strike the trunk of the tree with cambium so it can turn off the function of transporting nutrients and nutrients. Observations on the disease of cancer found a variety of hole that contains mucus.

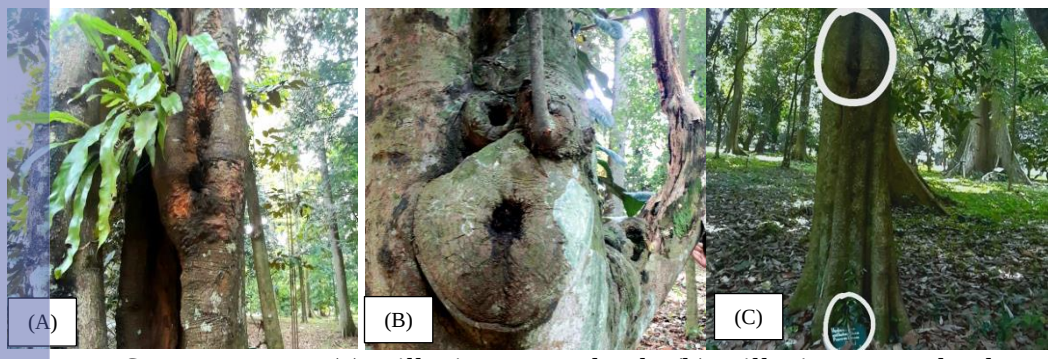


Figure 4 Stem cancer on (a) *Dillenia retusa* Thunb. (b) *Dillenia retusa* Thunb. var. Integra. Boerl. (c) *Hydnocarpus anthelminthica* Pierre ex Laness.

Cancer in the trunk on *Hydnocarpus anthelminthica* Pierre ex Laness. (figure 4 (c)), swallow exhausted old nametag contains the tree's identity, although the nametag large and made of iron, cancer can cover it so such a tree requires a new nametag.

Heart rot, Weathered wood, and Gall Rust (tumor)

Heart rot is damage to the tree caused by the pathogenic fungus Phytophthora sp. According to Sari *et al.* (2014) this disease usually attacks the plant, especially in the phase of seedling or sapling. The early symptoms of an attack can be recognized by base of the leaves that change the colour to yellow or brown due to the signs of necrosis underside of leaves. On mung beans, *Phytophthor*a sp. invade the base of the stem with the symptoms of the blight, and the plants wither and then die.

Surjokusumo and Karlinasari (2010) in Nugraha *et al.* (2019) stated that the leading cause of the disease is living organisms pathogenic or physical environmental factors. The fruit body on the trunk and branches is an indicator of weathered wood (punky wood) characterized by the presence of a network of softwood, containing water, and degradation (Pracaya 2003). Over time, wood became obsolete, there are also rot diseases of the liver (wet) which can attack the roots, stems, shoots, and fruit trees.

Figure 5 Tumors on (a) *Dillenia retusa* Thunb. (b) *Dillenia retusa* Thunb. var. Integra. Boerl.

Weathered and the body fruit on the tree belongs to the damage type of damage to Heart rot as found on the *Erythrospermum zeylanicum* (Gaertn.) Alston, *Dillenia retusa* Thunb. var. integra Boerl, *Flacourtia rukam* Zoll. & Moritzi, and *Alstonia scholaris* (L.) R. Br. in (Figure 5). Case of damage to the tree by Heart rot, Weathered wood, and Gall Rust (tumor) amounted to 19 cases or 36%. There's no sign of fruit-body but found weathered wood on branch of a tree by *Trichadenia zeylanica* Thwaites. Jamur Upas (*Corticium salmonicolor*) was seen on branch of tree as a sign of the symptoms of weathering during the rainy season with high humidity to support the development of mold spores.

The case of a tumor was found almost in all of the research plots. Swelling or *tumor* was found on the part of the tree, the size, and various quantities. So, the health status of the trees that are affected by tumors is also diverse. On *Dillenia retusa* Thunb. var. integra Boerl. (Figure 5a) there are many tumours around the stems of the upper part and the trunk at the bottom, whereas in *Hydnocarpus heterophylla* Blume and *Trichadenia zeylanica* Thwaites only found 1 of the tumor.

Open Wounds

Open wounds or gerowong (open cavity) on the trunk or branch of a tree trunk results of the weathering of the wood by destructive insects of wood (wood destroying insect). Nandika and Karlinasari (2014) stated that the open wound could lead to the uprooting of the trees, like a path of entry for the pathogenic cause of the disease, supporting the occurrence of weathering, and lowering tree's aesthetic value. Injuries that occur due to the damage because trimming main wood are calculated as the damage, but with the condition achieve a threshold limit damage and does not interfere with the integrity of the stem main of the wood.

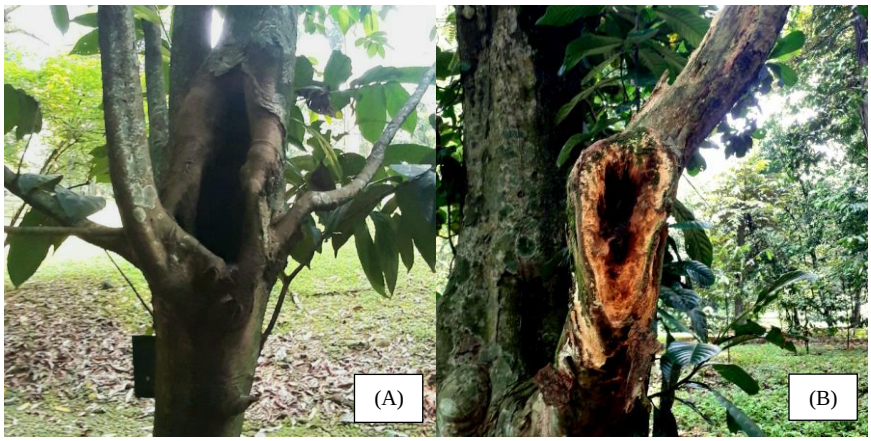


Figure 6 Open wound on (a) *Sarcocephalus coadunat* (Roxb, Ex Sin). (b) *Dillenia retusa* Thunb. var. Integra. Boerl.

Map of the spread of open wounds contained in appendix illustrates that the damage of an open wound that meets the threshold value of the damage is in plot 3 and plot 2. On a plot of 3 damage, there is on the stem below the *Sarcocephalus coadunat* (Roxb, Ex Sin) (Figure 6), *Flacourtia rukam* Zoll. & Moritzi, *Flacourtia rukam* Zoll. & Moritzi and *Dillenia retusa* Thunb. var. Integra. Boerl. *Dillenia retusa* Thunb. var. integra Boerl. isn't yet to known reason for gerowong because isn't relevation of indications or other indications of harm notwithstanding such gerowong. Dahlan (1992) recommended that the open wound damage depend on its area, and injury is partitioned into two section, particulary injuries on skin outside of wood and injury on timber skin and sapwood and teras wood. Sites of infection of open wounds are very useful for pathogen as plant tissues that are susceptible to infecting the tree.

Stem Fracture

The type of damage to the stem fracture at the study site is relatively small as much as 1 case (2%) reach minimum classification for threshold. The tree's trunk broke the damage to the rod, which is under the header of life or are on the tree that is still alive. On the tree of *Tabermaemontana aurantiaca* Gaudich (figure 7), there's an open wound (gerowong) which is thought to cause stem broken by logging maintenance, and there is the fault of stem rot. If branch is broken is left without treatment would further the cause of infection or other damage.

Figure 7 Broken stem on *Tabermaemontana aurantiaca* Gaudich.

Broken Root

There was only one damage due to a broken root found. Broken root found *Myristica lancifolia* Poir. Van. Lancifolia (figure 8) at plot 2, may be due to open wound on the first or injured because it is exposed to lightning. This damage isn't encountered damage to others from pest attack in addition to the roots are broken. The tree remains alive and grow productively. Maintenance of a fallen tree due to roots a broken or dead due to lightning, or wind can be done by cutting the trees to leaves ¼ the bottom of the tree.

Figure 8 Broken Root on *Myristica lancifolia* Poir. Van. Lancifolia.

Broken branches

Broken branches or dead only found on the plot 4 with two cases. Pracaya (2003) stated that parasitic diseases and pests may the result of the death of a branch. The symptoms that occur can be seen by the presence of dead branches or leaves.

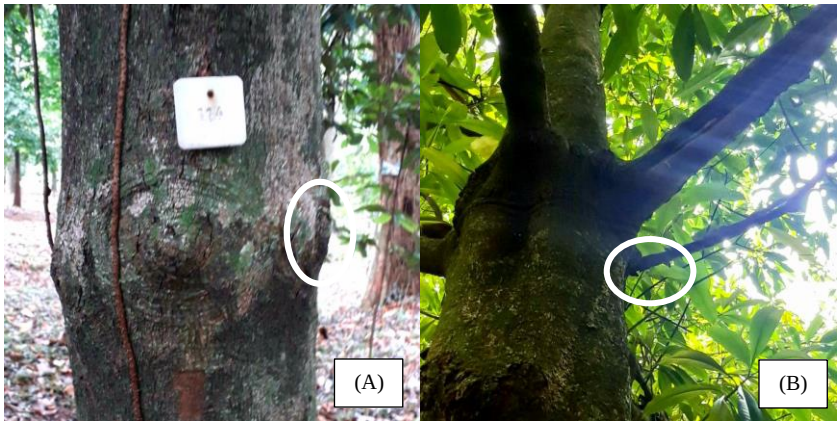


Figure 9 Broken Branches on (a)*Cerbera* sp. (b)*Alphonsea ventricosa* (Roxb.) Hook. f. & Thomson

Leaves, buds, or shoots damaged

Damage to the leaves, leaf buds or shoots can be due to the inedible insects, other pests, attacked by bacteria and fungus, and strectched buds. There was only one cases (2%) on plot 1 on *Hydnocarpus venenanta* Gaertn. Damage on the leaves requires *Hydnocarpus venenanta* Gaertn. live with the rest of the 20% of the leaves are supposed to be there. On *Dillenia reticulata* King. there was also tumor so that the leaf damage severe supported by the presence of tumors that interfere with the growth of the tree, this is following statement which state that the tumor influences to interfere with the development due to Wiryadiputra (2007).

Figure 10 Leaves Damages on *Hydnocarpus venenanta* Gaertn.

While at plot of 2, the damaged leaves that characterized with small holes on the leaves are spread evenly on *Dillenia reticulata* King. Small holes are caused by pests or pathogens that attack the leaves on the tree, but because the damage that occurs doesn't meet the threshold value of damage, so the tree is catagorized healthy.

Figure 11 Leaves Damage on *Dillenia reticulata* King.

Liana woody

Liana is one of the species characteristic typical of tropical rainforest ecosystems. The plant's existence in this climber adds to the biodiversity in the ecosystem. Liana climbing and sustains himself on other plants to reach the trees at a certain height. The type of damage liana is the most common case of damage found in the study area with 14 cases (30%) that spread evenly throughout the study location.

The worst damage caused by liana is found at plot 1 on *Scolopia spinosa* (Roxb.) Warb. (Figure 12 a). Liana successfully fused with the tree and dominated the tree's growth, leaving the tree to have two morphologies of different leaves. Both the morphologies of the leaves are derived from the leaves on the liana and tree leaves of *Scolopia spinosa* (Roxb.) Warb.. Asrianni *et al.* (2008) stated that liana also could sores on the tree's trunk and pick up the food so that it interferes with the growth of the host plant. The cause a various of disorders, liana continues to have a positive role in preventing the uprooting of the trees because of its creeper, as a livestock feed, and animal advocates passer.

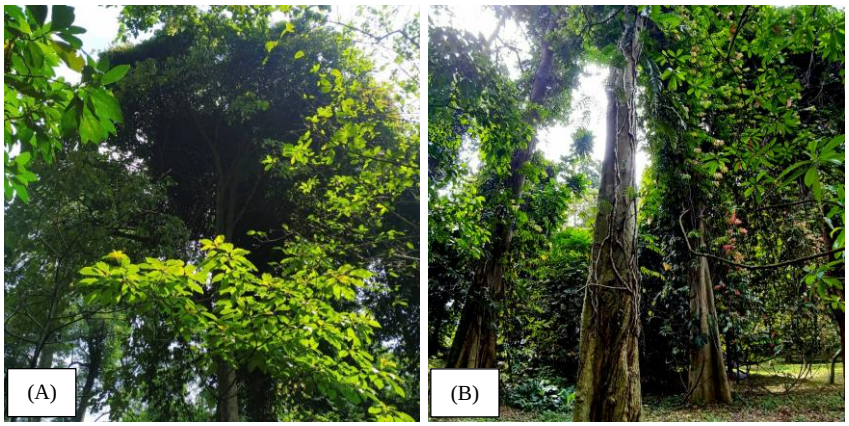


Figure 12 Liana on (a) Liana on *Scolopia spinosa* (Roxb.) Warb. (b) *Alstonia macrophylla* Wall. ex G.Don

High diversity in the ecosystem of tropical rain forests provides a structure of the vertical and horizontal complex. All types of plants need water, nutrients, oxygen, carbon dioxide, soil moisture, and the sun's light, and to meet the needs,

sometimes several types of plants compete. Liana tends to climb, vines, wrapped around the trunk, branches, and canopy trees to get sunlight (Simamora *et al.* 2015).

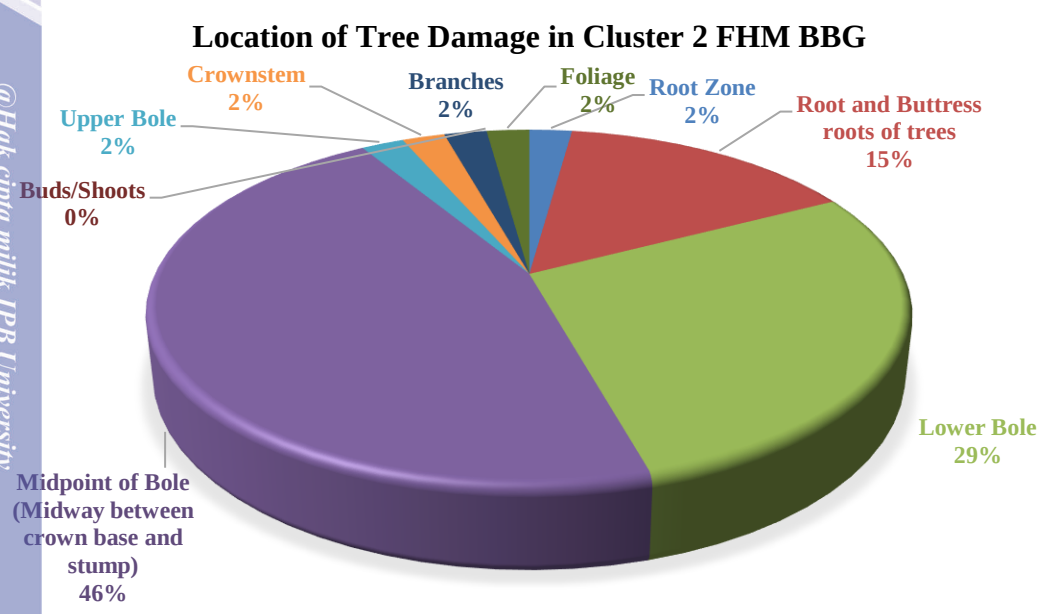


Figure 13 Precentage of location of damage cases found in Cluster 2 FHM BBG

The location of the damage on a tree is divided into 9 locations following the rules of USDA-FS (1997) for Forest Health Monitoring. The damage location with the highest case is on the stem. There are 21 cases of damage (45%) found at the fourth location or midway between the crown base and stump (midpoint of bole), lead this damage location as the most significant number of damage locations. Damage at the bottom rod (location 3) and the roots and bottom stems (location 2) hold a percentage of 28% and 15%, respectively. On the root zone, upper bole, crown stem, and foliage, only 1 type (2%) of damage was found. Damage on the crown (location 9) was not found in Cluster 2 FHM BBG.

The trunk of the tree suffered a lot of damage. Midway between the crown base and stump (midpoint of bole) having a wide range of damage including liana, cancer, and tumors of each as much as 13, 2, and 6 cases. The tree's trunk is the backbone of the crowns and the organs of the buffer system of transport for the distribution of nutrients. Widyastuti et al. (2005) stated that stem plays a role in the process of the survival of a tree that ranks third after the roots and leaves. The space of the roots and the stems has a crucial job for plants. Assuming the harm happens nearby, it can meddle with the interaction of assimilation of water and minerals from the roots to the entire organization of plants that can restrain the cycle of photosynthesis and will affect the decrease like physical and physiological trees.The type of damage that dominates at the roots and the stump and the roots and stems of the lower part is type 2, i.e., gall rust (tumor), heart-rot, fruit body, and other indicators of the weathered wood. As absorbing nutrients and water need by the plants, the root is the key organ to a tree's survival. The roots physically are the backbone of the founding of the tree, and if found any damage on the roots can weaken the function of the root so that it can cause problems on tree growth or harm the trees.

There was only 1 case (2%) of damage found at the branch in the form of broken branches that meet the value of the damage threshold. The damaged location is very vulnerable with a high risk of broken branches, and any time they could fall and hit visitors. The location of the damage on the branch of a tree is difficult to reach and requires climbing for trimming.

The type of damage on the leaves was also found in only 1 case (2%) of the overall observed trees. This type of damage on leaves only 20% of the healthy leaves on the tree should be present. A result of this damage is the obstruction of the process of plant growth caused by delays in the process of photosynthesis as the primary function of the leaves.

3.3 Tree Level Damage

A tree that isn't experienced damage is a very healthy tree tree that is resistant to damage, can adjust to a pathogen, or cause other damage that doesn't affect the growth and productivity of trees is a very healthy tree. While the trees are suffered minor, moderate, or severe damage categorized as a tree that isn't resistant to damage. Abiotic and biotic factors can cause tree damage, so the negative impact of the occurrence of the damage to the tree will loose of the quality of the wood, and the disrupt of the health of the forest folk (Abimanyu *et al.* 2019).

Tabel 7 Health Level of Trees and Plot Level Index Score

Observation Plot	Health Level					PLI
	Very Health	Healthy	Broken Light	Moderate	Heavy	
Plot 1	4	5	1	0	0	2.57
Plot 2	13	6	1	2	0	2.43
Plot 3	9	3	5	0	0	3.06
Plot 4	6	6	1	2	0	3.66
Cluster Level Index						2.93

The value of lowest PLI on the plot 2 amounted to (2.43) showing a low damage rate compared with other plots that experienced most severe damage. The lower the value of the level of damage to the tree, it can be said the health status of the trees and the area is healthy, while on a plot of one, three, and four have a value of PLI each of 2.57, 3.06, and 3.67. The value of PLI was highest on a plot of three compared to the plot of one and four. Value of PLI incredibly influences the level of health in Cluster 2 FHM BBG, because the higher the value of PLI on the location of the study showed the significant damage or a state that is not healthy at Cluster 2 FHM BBG.

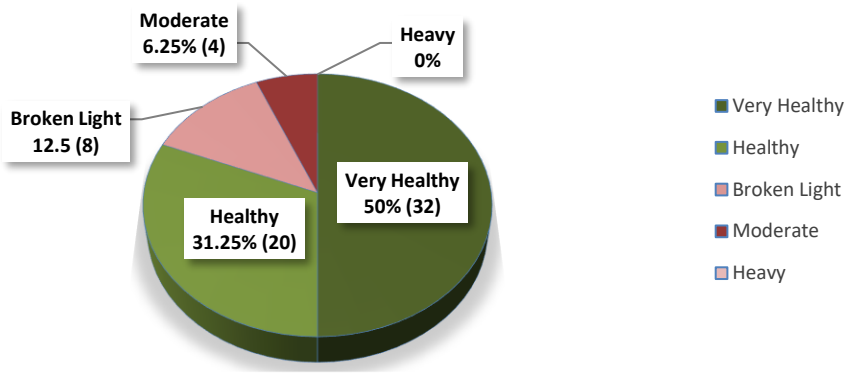


Figure 14 Relativity between Tree Health Level against the quantity of trees.

The results of the assessment of the three parameters, namely the location, type, and severity of the damage reached the threshold of severity will show the health status of each tree in the location of the observation. The damage is considered in two different levels, namely at the level of the tree (TLI – Tree Level Index) and plot-level (PLI – Plot Level Index). The results of the assessment TLI showed that 32 of the trees (50.0%) were in the conditions of very healthy or no damage at all. Twenty trees (31.25%) in a healthy condition with very little damage, eight trees (12.5%) at the condition of broken light, four trees (6.25%) at the condition of broken, and there was no tree found in a badly damage condition. TLI conditions of broken and damage cancer with the severity of ≥ 20% at the point of observation or conk is the condition of the damage with the tendency could not be recovered even can cause the death of the tree. Most of the trees in the Cluster 2 FHM BBG that dominated by family Apocynaceae, Myristicaceae, Flacourtiaceae, Achariaceae, and Salicaceae were in a healthy condition.

3.4 Maintenance for Trees Collection and Treatment Recommendation to the Trees in Cluster 2 FHM BBG

Forest maintenance is an activity that is very important in providing opportunities for the plants to grow optimally. The actions of the maintenance of the forest include several activities. Usual activities are maintenance with watering, fertilizing, weeding, pruning, pest and disease controlling, and cleaning. Watering and fertilizing are carried out on young plants. Fertilizing is carried out using organic fertilizer (compost) by utilizing fallen leaves around the tree a collection of Bogor Botanical Garden. Weeding is done by removing the lawn or weed to prevent competition to nutrients and water. Pruning is carried out on a dead branch or a rotten and liana is strangling the tree trunks and branches of trees that can harm the visitors.

Trees attacked by pests and disease required more effort to prevent damage to the plants from getting worse, by attempting the most straightforward and fast way to remove the parts of tree damaged by pests and diseases. In addition, it can also be done with pesticide or drug eradication of pests and disease on the surface of the diseased parts of the tree. The presence of some type of damage, such as open wounds, cancer, termites, cracks on the stem, and the tumor on the tree it will affect the growth, development, and health of the tree (Supriyanto *et al.* 2001 in Cahyono 2014). Mechanical control can be done with the eradication, painting the wood by oil, and sanitation. Physical control is carried out with the setting sunlight to enter the forest floor to keep the moisture thereby inhibiting the growth of fungi. This technique can be done using thinning or cleaning the weeds. Biological control can be done by breeding natural enemies of fungi causing cancer in the tree. *Trichoderma sp.* is a biological agent that is known effective in suppressing the growth of fungi. The granting of *Trichoderma sp.* can be done by inoculating the species on the soil around the tree in the approriate areas or spraying directly on the area of cancer in some selected trees. Appropriate implementation of *Trichoderma sp.* can result in the development of fungi cause rotting further inhibited. Chemical control can be done by spraying pesticides and fungicides. Action for the eradication of pests and diseases is rarely done. However, the best effort should be made is by monitoring the trees that suffered damage so that we can avoid things not to refrigerate that can harm the visitors because to avoid harm the visitors.

The cleanliness of the area is also a significant factor, given the Bogor Botanical Garden is a tourist and educational object. The garbage that is always cleaned and sorted between organic and inorganic. Then the organic waste can be processed to compost. Organic waste around the tree is also not ideally removed because it is useful to reduce the evaporation of groundwater. In addition to ensuring that plants grow optimally, maintenance in BBG also aims to prevent the occurrence of losses, both physical and material, caused by damage to the tree. The trees management with the value of the damage to the trees should be monitored regularly using the most appropriate method. The information of the existence of such trees is undoubted to be notified to the visitors so that visitors can travel safely and comfortably, as well as avoid the tree damage.

IV CONCLUSION AND SUGGESTION

4.1 Conclusion

Type of damage to the tree found at Cluster 2 BBG showed a total of eight types. The most damage type found are a Heart rot, Weathered wood, Gall Rust (tumor) of 36% of the total cases found. The most often damage location found with a total of eight from nine areas was located on the midway between crown and stump (46%). Value of CLI by 2.93 indicates that trees at Cluster 2 FHM categorized in a healthy condition. The lowest PLI found on Plot 2 of 2.43 shows healthy status of the trees in the area. Trees with the worth of the harm to the trees should be monitored periodically by using the proper technique and the data of the presence of such trees should be advised to the guests, to guarantee their safe travel.

4.2 Suggestion

The information provided on the trees and the their health status is a preventive action for visitors, especially on trees that are considered prone to uprooted by providing a written warning. Development of Forest Health Monitoring methods in hometown city and the maintenance and prevention of damage to trees in Bogor Botanical Garden should be performed periodically to maintain the health of the trees, guarantee visitor safety, and escalating environmental sustainability of the city.

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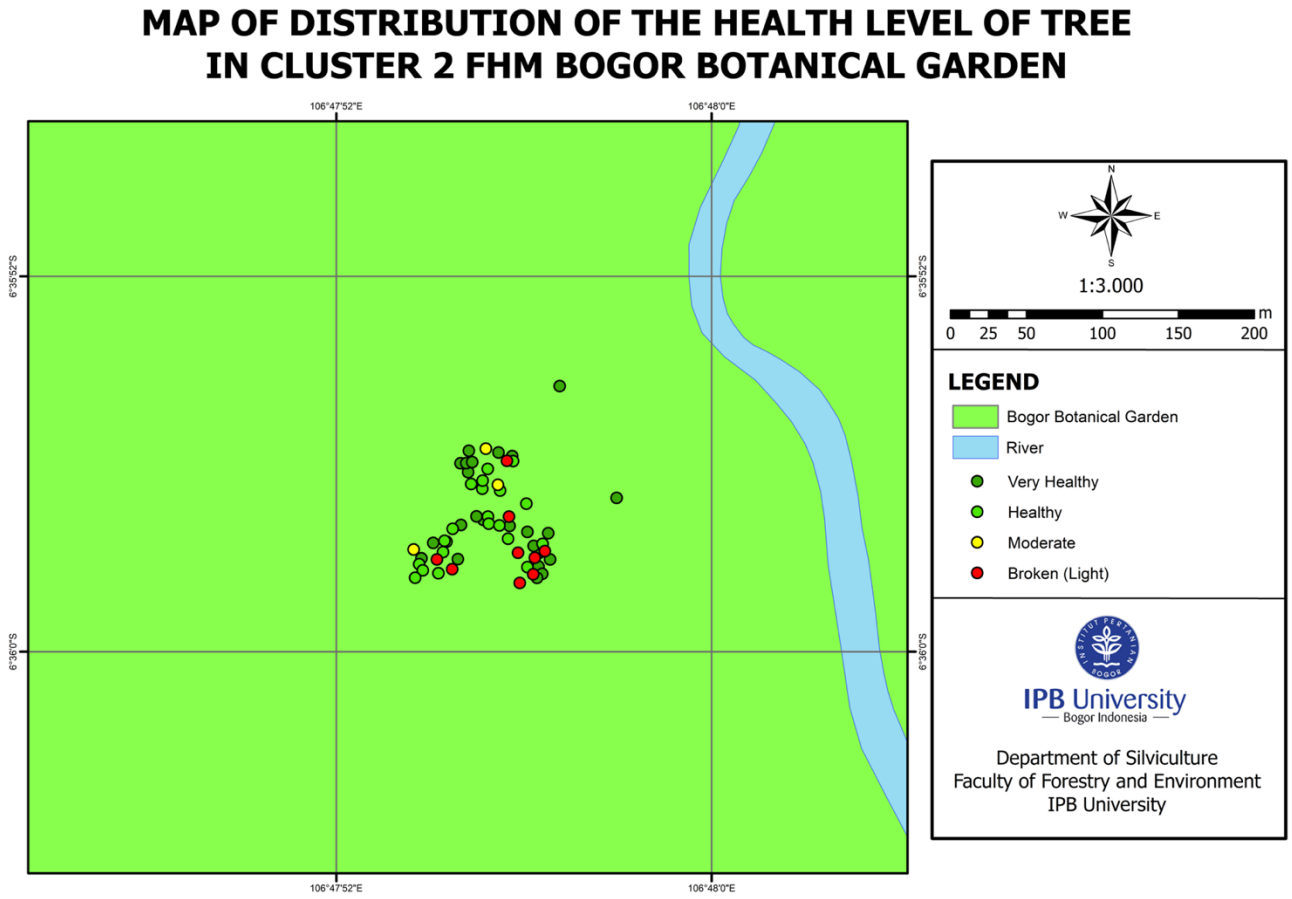
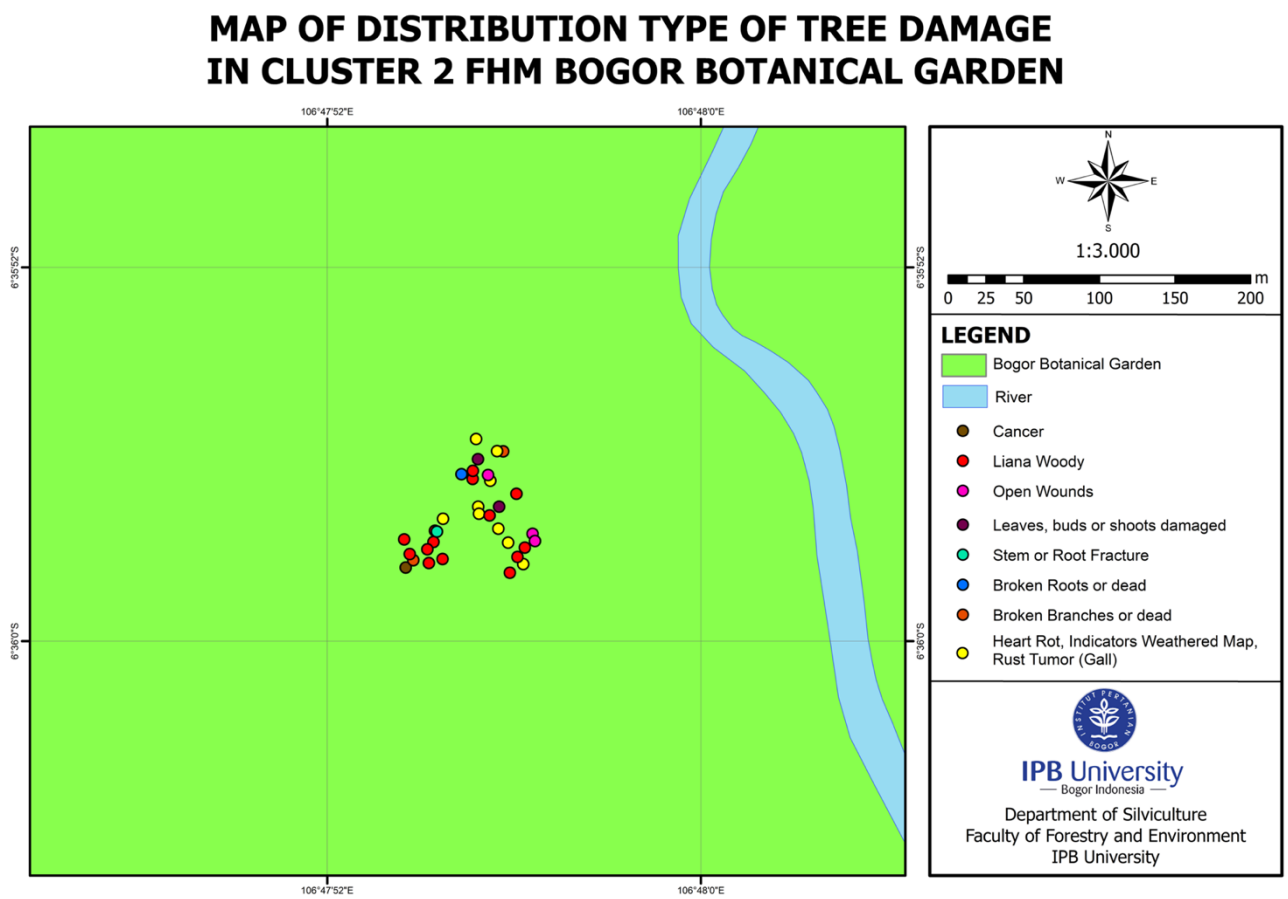
APPENDICES

Apendix 1 Map of Distribution of the Health Level of Trees in Cluster 2 FHM Bogor Botanical Gardens



Source: Head of Registration Subdivision BBG 2021

Apendix 2 Map of Distribution Type of Tree Damage in Cluster 2 FHM Bogor Botanical Garden



Source: Head of Registration Subdivision BBG 2021

CURRICULUM VITAE

The author was born in the city of Banjar on 7 July 1999 as the first child of the couple's dad Irwan Nuryana Kurniawan and mom Rika Kadarwati. She completed her High School reached in MAN Yogyakarta 3, graduated in 2017. In 2017, the autor start her undergraduate program (S-1) in the Department of Silviculture, Faculty of Forestry, IPB.

During her undergraduate study, the authors actively participated in various committees and organizations. The author experienced Forestry Field Work in the Drajat-East Sancang (Garut) and Gunung Walat Educational Forest (HPGW). She performed a Laboratory Assistant at General Competency Education Program (PPKU)for lecture Physics 101 in the academic year 2019/2020. In July-August 2020 the authors completed her community service program (KKN-T) in Sleman Regency, Special Province of Yogyakarta.

The author conducted her research final project (undergraduate thesis) which began in March 2021. Her final project entitled “Tree Health Analysis for Apocynaceae, Myristicaceae, Flacourtiaceae, Achariaceae, and Salicaceae Families in Bogor Botanical Gardens (BBG)” supervised by Dr. Ir Elis Nina Herliyana, MSi, and Arief Noor Rachmadiyanto, SP MP has been done as perquisite to obtain a Bachelor's degree in Forestry at the Faculty of Forestry and Environmental IPB University.